DØ New Phenomena Group Plans

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BROWN UNIVERSITY

DØ Collaboration Meeting
April 26, 2002

A Bit of Statistics

- Search for New Physics is one of the most exciting topics for Run 2A:
  - Double the current sensitivity for most of the searches
  - Explore very interesting regions of parameter space in various models of new physics
- This is reflected in strong interest to our research program from both theorists and experimentalists:
  - Run 2 SUSY/Higgs, Strong Dynamics workshops
  - Many "LHC groups" joining DØ and the NP group
- So far, we are the largest physics group in DØ:
  - 148 people on the mailing list
  - 27 officially assigned physics topics, many more to come
  - 4 theses already defended with limited use of Run 2 data
  - up to 7 additional dimensions
  - …

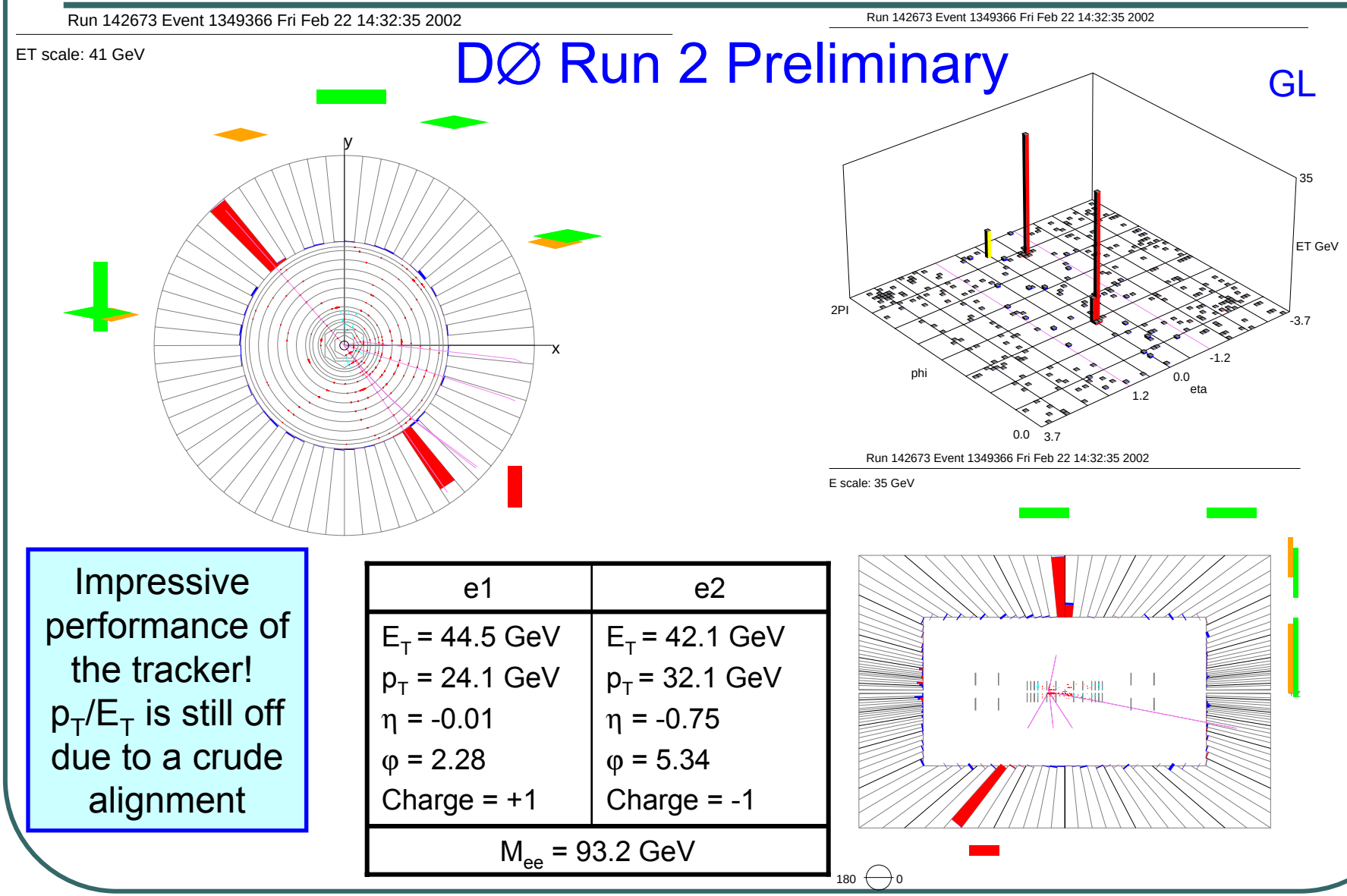
Ongoing Analyses

- Leptoquarks:
  - eejj – Shaohua Fu, Vishnu Zutshi, Rick Van Kooten
  - μμjj – Tim Christiansen, Frank Fiedler, Xiaofei Song
- Extra Dimensions:
  - ee+γγ – GL
  - μμ – Ryan Hooper
- RPV SUSY:
  - trileptons in e, μ channels – Pavel Demine, Gerard Sajot
  - dilepton + jets – Auguste Besson, Gerard Sajot
  - likesign dielectrons – Brent Wang
- GMSB SUSY
  - γγ+ME_T – Stelios Kesisoglou, Yuri Gershtein
- SUGRA SUSY
  - squarks and gluinos (jets+ME_T) – (Melissa Ridel), Jean-Francois Grivaz, Laurent Duflot, Patrice Verdier
  - b-squark 2-body decay (jets+ME_T) – Frederic Villeneuve-Seguier, Mossadek Talby
  - b-squark 3-body decays (ee+jets+ME_T) – Stephanie Baffioni, Elemer Nagy
  - Trileptons in dimuon channels – Adam Yurkewicz, Roger Moore, Serban Protopopescu
  - eμ+X – Daniel Whiteson, Mark Strovink

Moriond Snapshots

- Thanks to focused efforts of a number of people from our group, we produced many results for the Spring conferences
- This helped DØ to look strong at Moriond/LaThuile (per multiple accounts)
- It was clear from the reaction of the audience that it was surprising for people that DØ managed to produce so many results with just 5 pb^{-1} of data
- Here is a snapshot of some of our conference results and brief review of what has changed since the Moriond
- Also, several new analyses are expected to have conference-quality results for the summer

First Z(ee) Candidate w/ Two 3D-tracks

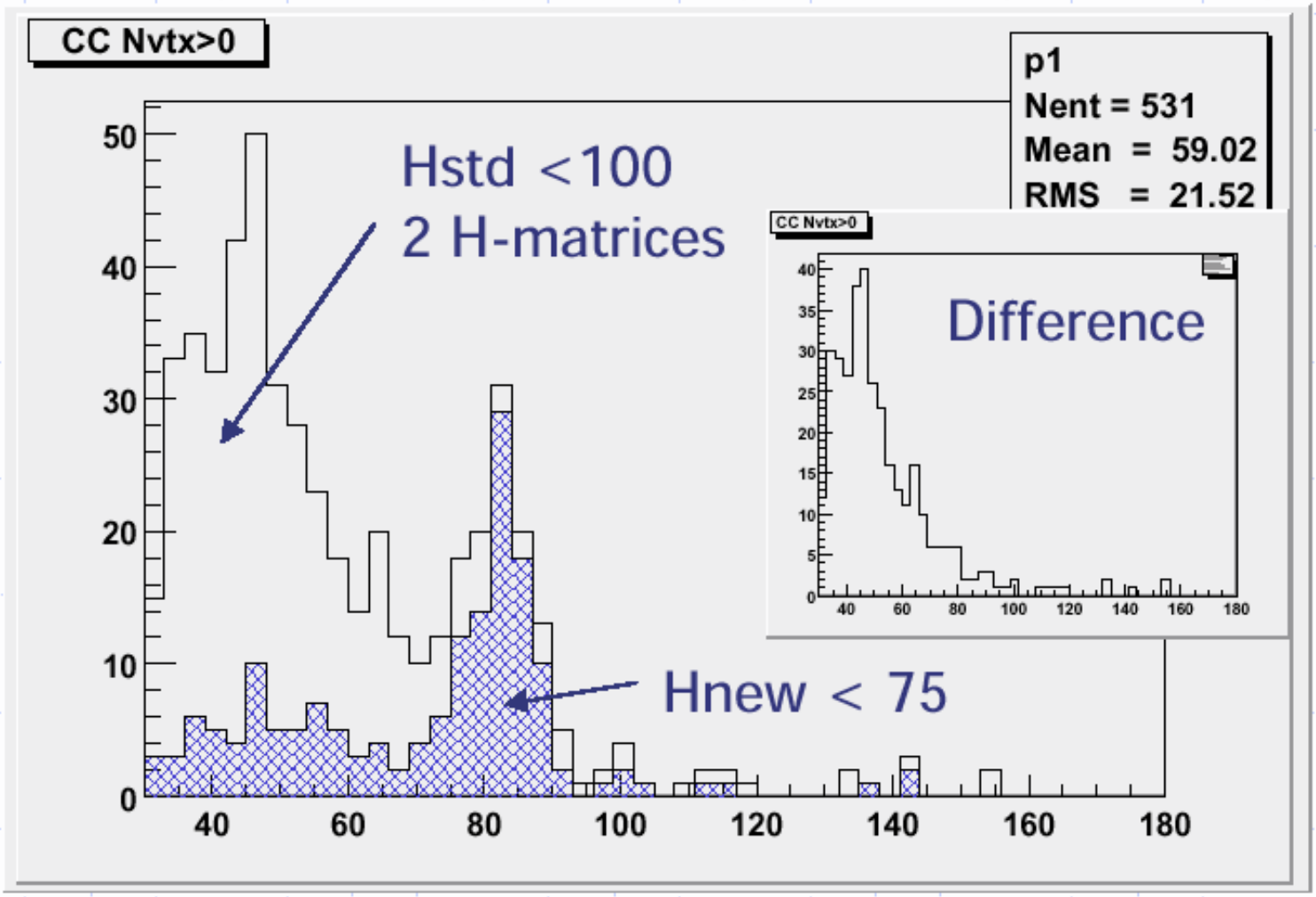


Impressive performance of the tracker! p_T/E_T is still off due to a crude alignment

e1	e2
E_T = 44.5 GeV	E_T = 42.1 GeV
p_T = 24.1 GeV	p_T = 32.1 GeV
η = -0.01	η = -0.75
φ = 2.28	φ = 5.34
Charge = +1	Charge = -1
M_{ee} = 93.2 GeV	

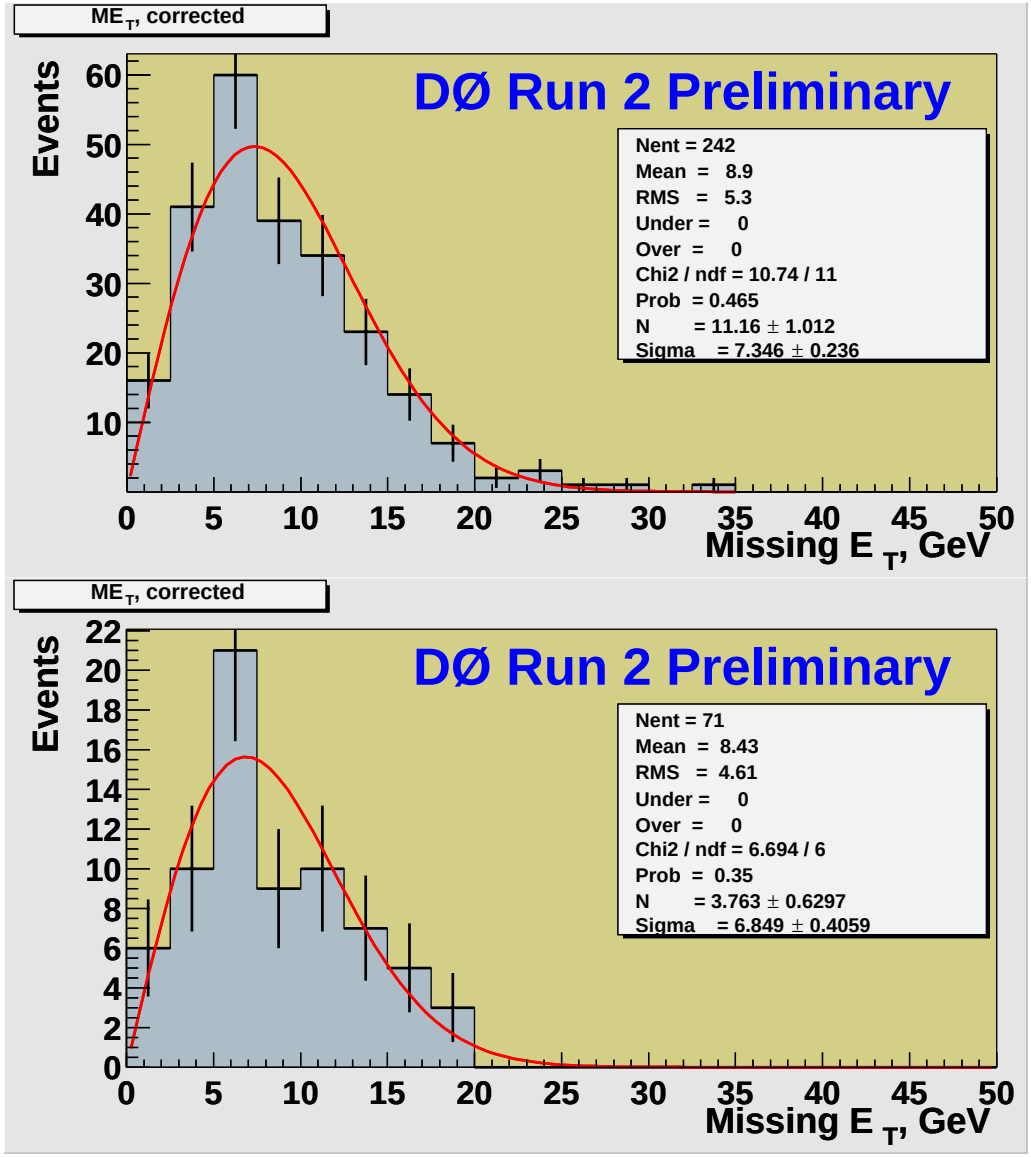
Since the Moriond

Yuri Gershtein, Alex Melnitchouk



diEM+ME_T Channel

GL

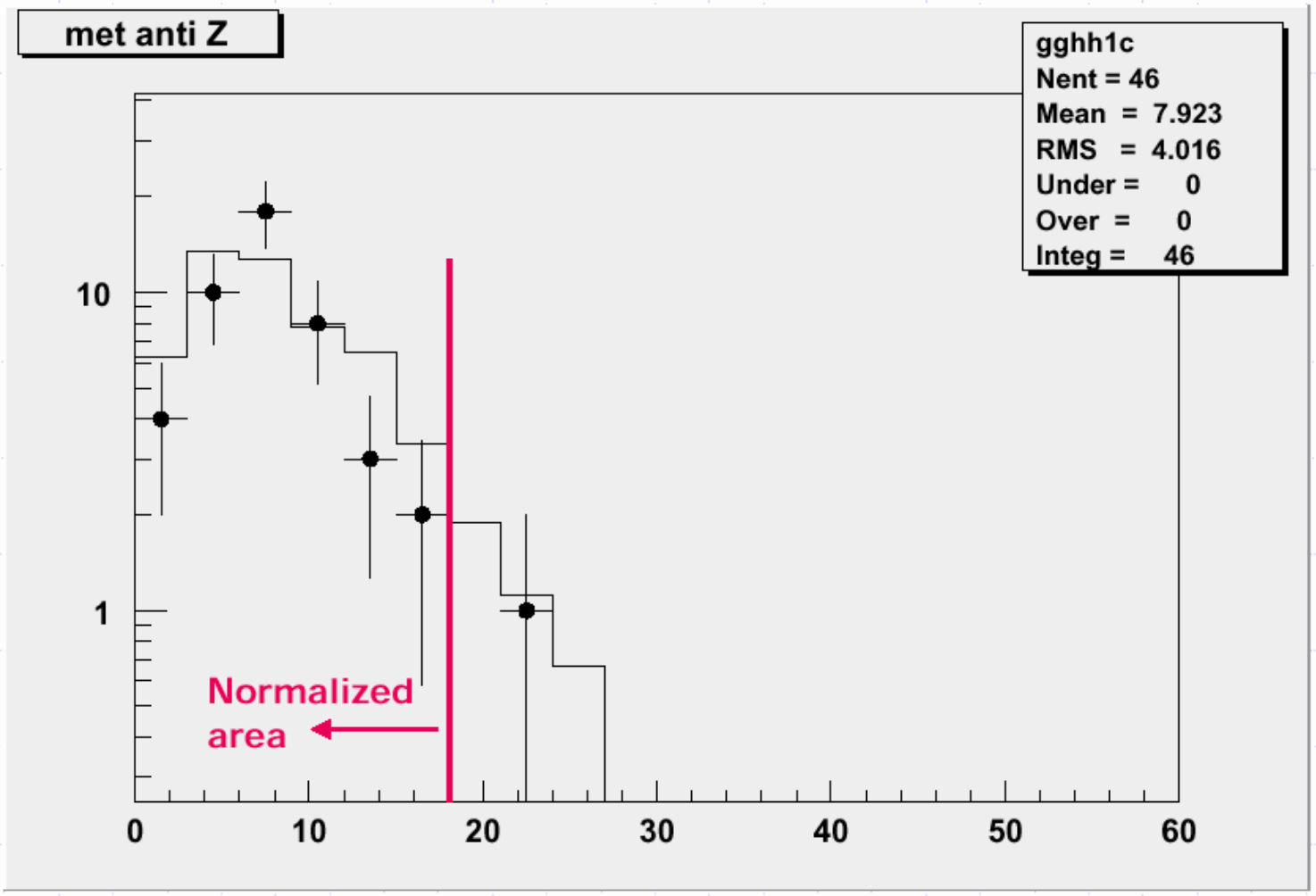


- $\gamma\gamma$+ME_T is an important channel for new physics searches (GMSB SUSY, radiative neutralino decays, extra dimensions, etc.)
- The key is a good ME_T resolution and low non-Gaussian tails
- Top plot: ME_T in the inclusive diEM sample
- Bottom plot: ME_T in the diEM sample w/ at least one matching track
- Red line shows the fit to a resolution function:

$$f(\not\!\!E_T) = N \frac{\not\!\!E_T}{\sigma} \exp\left(-\frac{\not\!\!E_T^2}{2\sigma^2}\right)$$

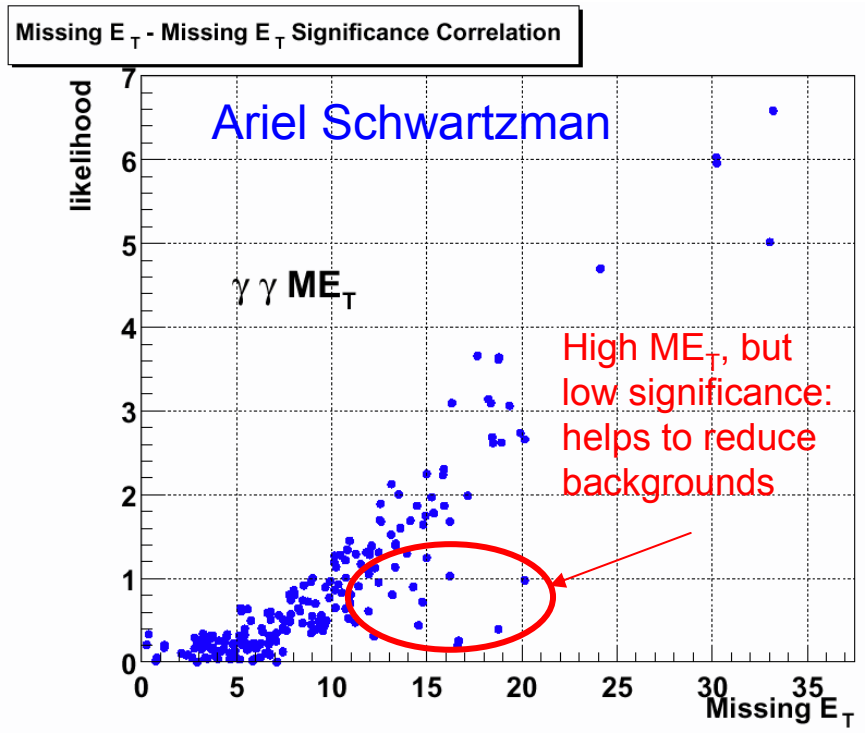
Since the Moriond

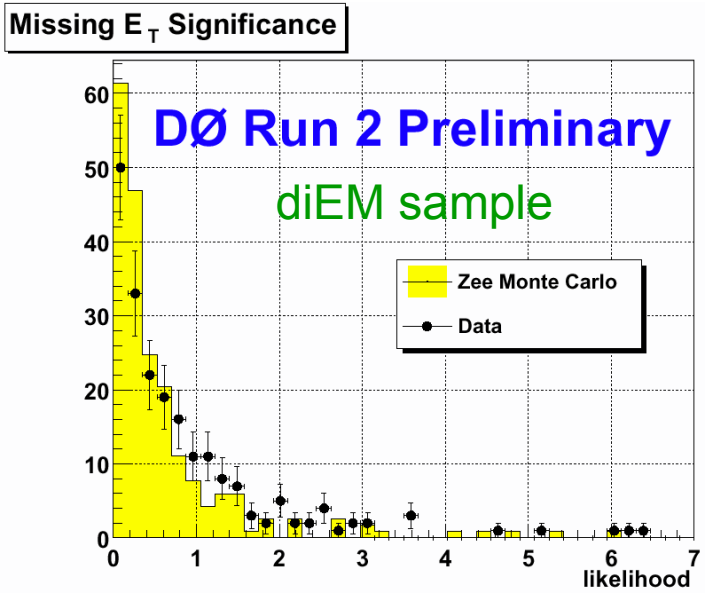
Yuri Gershtein, Stelios Kesisoglou

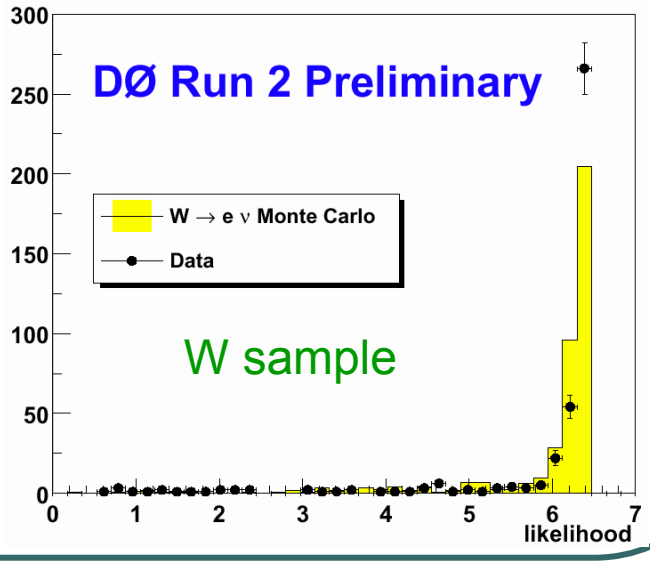


ME_T Significance

- One can use a likelihood quantity, the "MET significance" to improve S/B by taking into account event topology, found vertices, and resolutions
- Low significance correspond to no physics source of MET;
- High significance means that MET is likely not due to mismeasurement



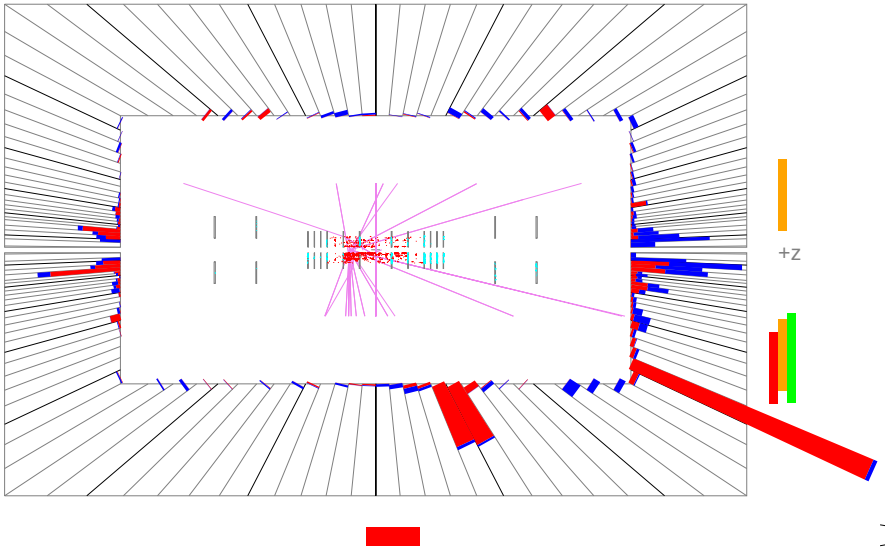




Highest-ME_T diEM+ME_T Candidate

Run 144571 Event 690485 Tue Feb 26 17:31:50 2002

E scale: 25 GeV



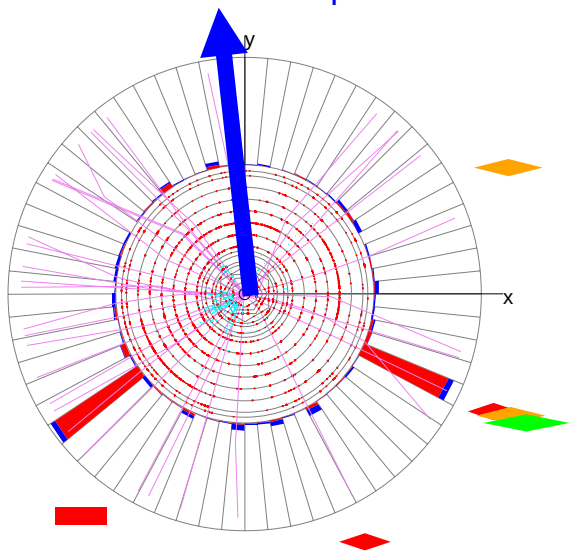
180 0

-2.5 2.5

Run 144571 Event 690485 Tue Feb 26 17:31:51 2002

ET scale: 28 GeV

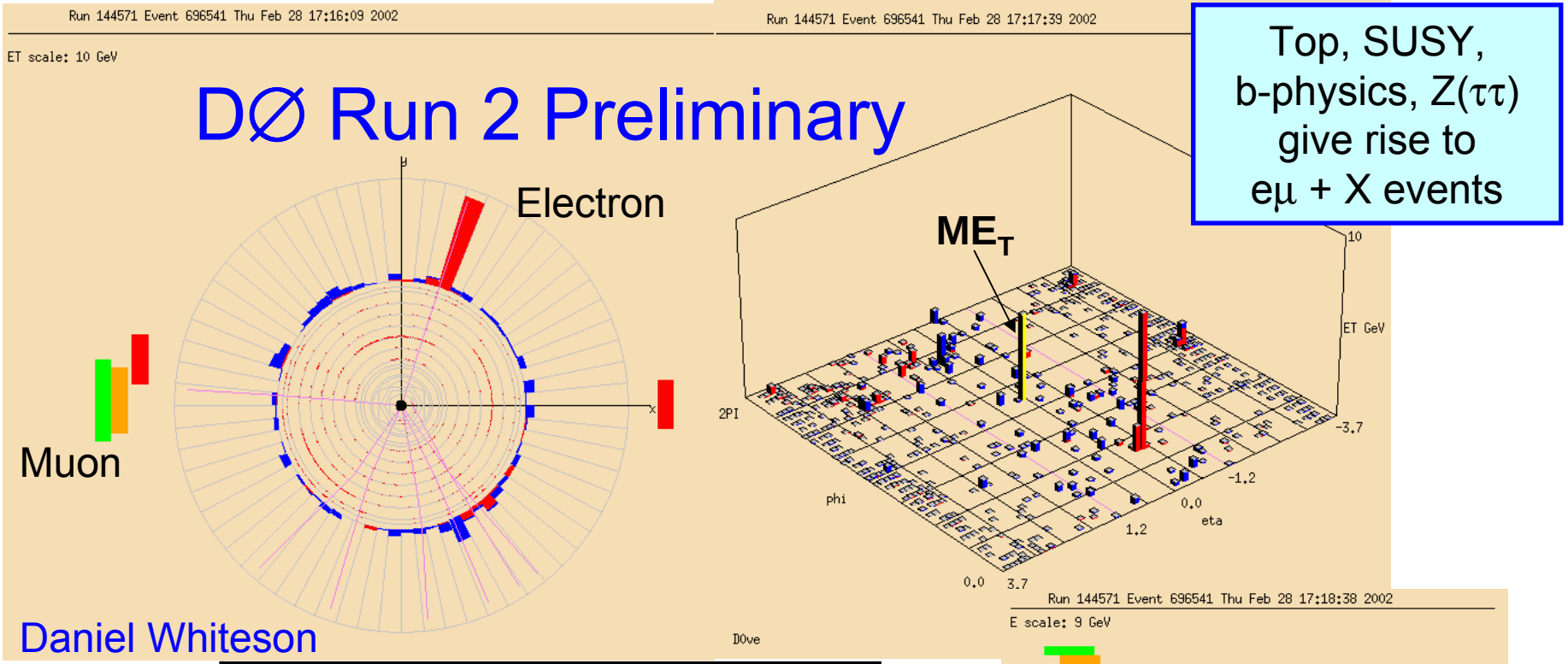
ME_T GL



EM1	EM2
E_T = 27.4 GeV η = 0.52 φ = 3.78 Loose match with a low-p_T track	E_T = 26.0 GeV η = 1.54 φ = 5.86 No track match
ME_T = 34.3 GeV; M(diEM) = 53 GeV	

An interesting event, as it cannot be explained with a vertex mismeasurement. Can be explained by the resolution effects.

eμ Candidate Event



Top, SUSY, b-physics, Z(ττ) give rise to eμ + X events

e	μ
E_T = 13.9 GeV p_T = 9.3 GeV η = -0.425 φ = 1.251 Charge = -1	p_T (toroid) = 16.4 GeV p_T (central) = 6.3 GeV η = -0.461 φ = 2.967 Charge = +1
ME_T = 6.0 GeV	

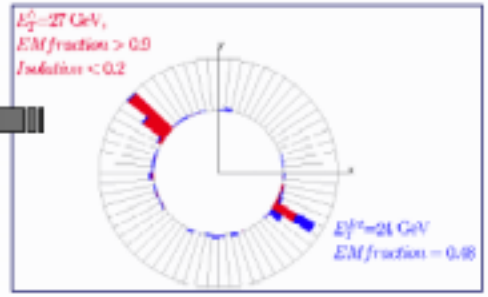
Since the Moriond

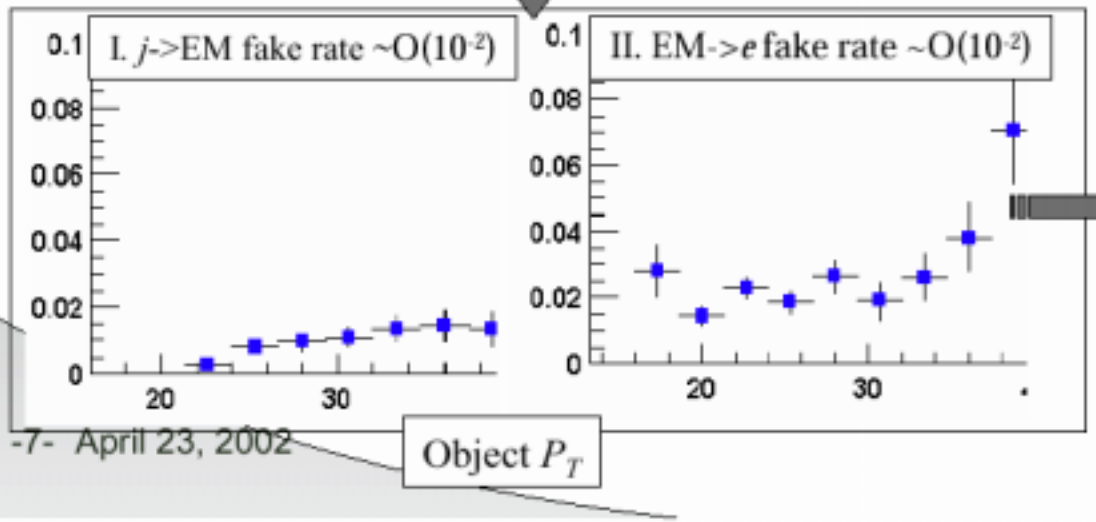
Fake rate will be further reduced with the new H-Matrix

Examine a sample of jets from γ+jet and di-jet events. From the fraction of those that pass our two stages of electron identification:

I. Calorimeter requirements: isolation, EM-fraction,…

II. Track confirmation



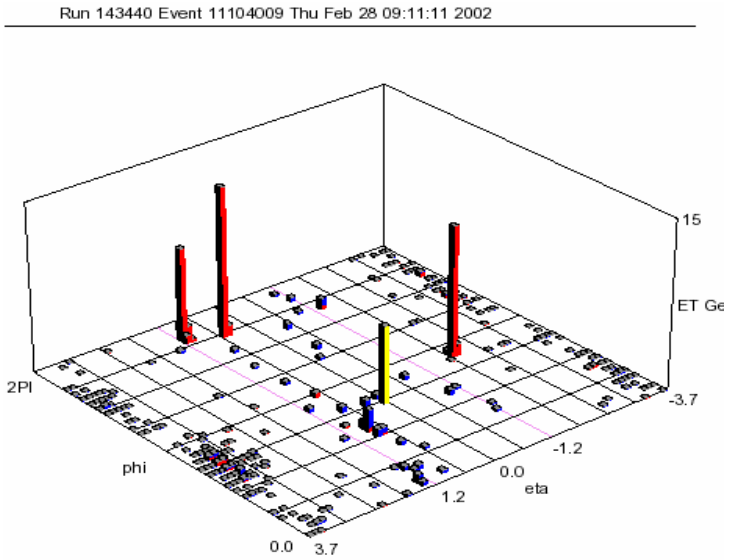


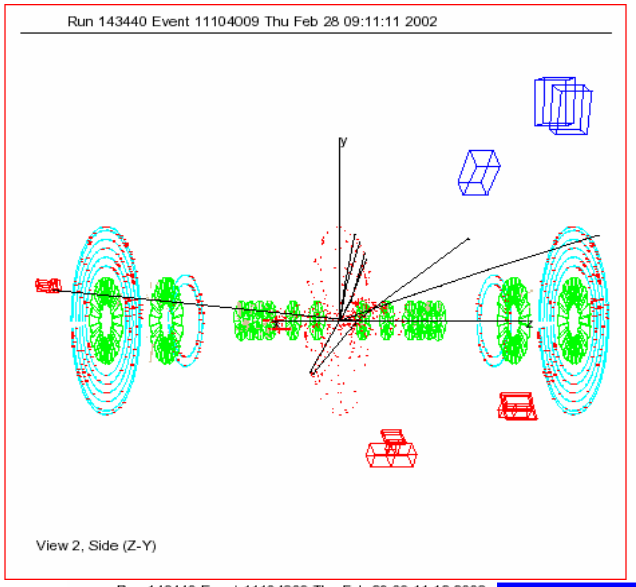
We can extract P(*j*->"*e*") ~ O(10^{-4}) Apply that fraction to the large observed sample of μ+jet events to model the fraction of $e\mu$ events that come from detector fakes.

Daniel Whiteson

eee Candidate Event

DØ Run 2 Preliminary

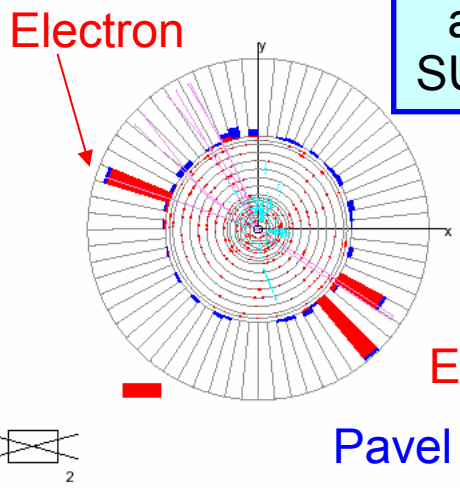




Run 143440 Event 11104009 Thu Feb 28 09:11:12 2002
ET scale: 15 GeV

e1	e2	e3
E_T = 17.9 GeV p_T = 0.52 GeV η = 0.43 φ = 5.42 Charge = +1	E_T = 13.9 GeV p_T = 10.9 GeV η = -1.94 φ = 2.80 Charge = +1	E_T = 13.2 GeV p_T = 15.1 GeV η = 1.06 φ = 5.72 Charge = -1
m_{e1e2} = 55.7	m_{e1e3} = 10.8	m_{e2e3} = 63.5
m_{e1e2e3} = 85.2 GeV/c^2		ME_T =10.7 GeV

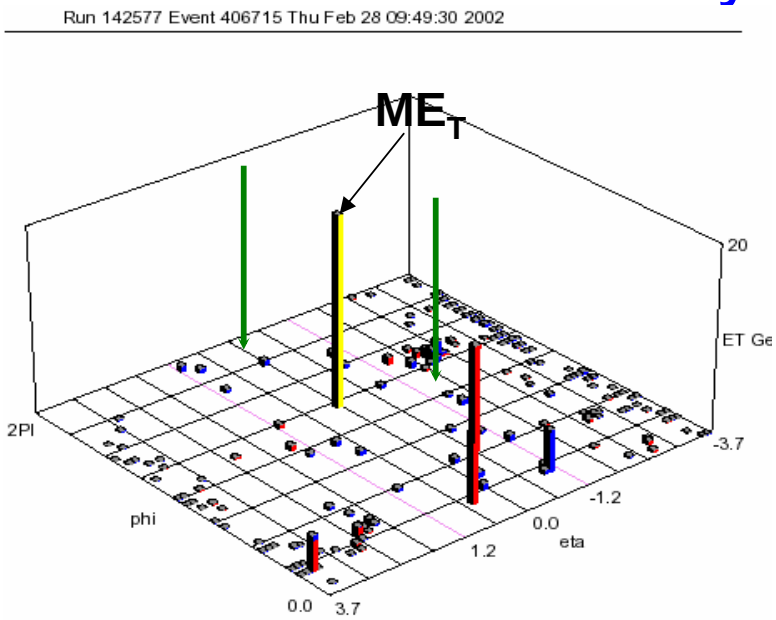
Trilepton events are classical SUSY signature

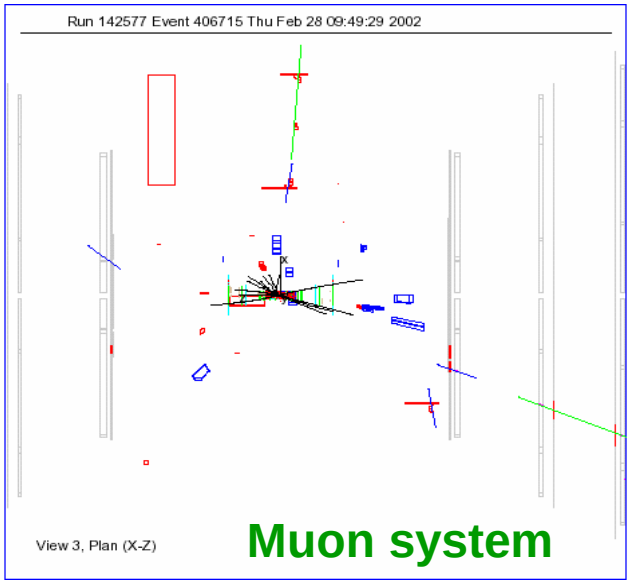


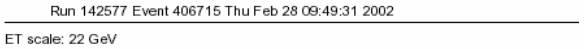
Pavel Demine

eμμ Candidate Event

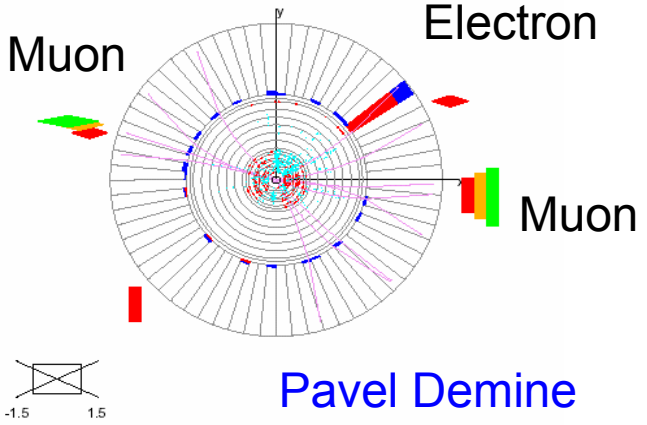
DØ Run 2 Preliminary







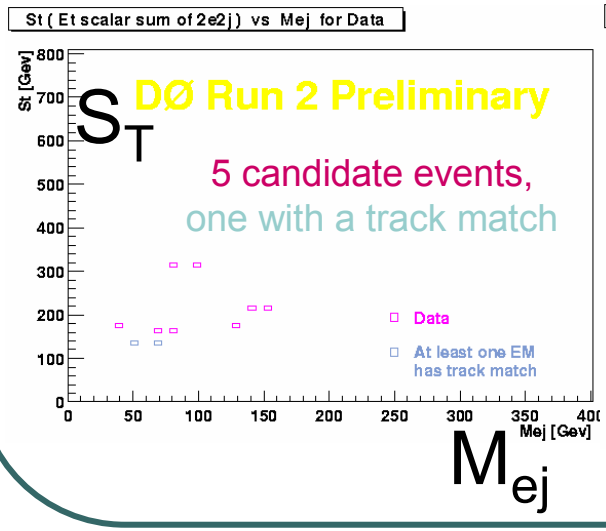
e	μ1	μ2
E_T = 19.2 GeV η = 0.40 φ = 0.63 No track match	p_T = 28.2 GeV η = -0.10 φ = 6.20 Charge = -1	p_T = 9.82 GeV η = -1.48 φ = 2.88 Charge = 1
	$m_{\mu\mu}$ = 41.5 GeV/c^2	
ME_T =31.8 GeV		

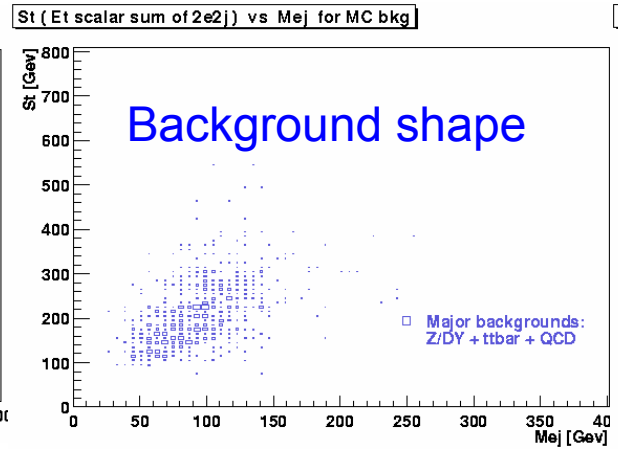


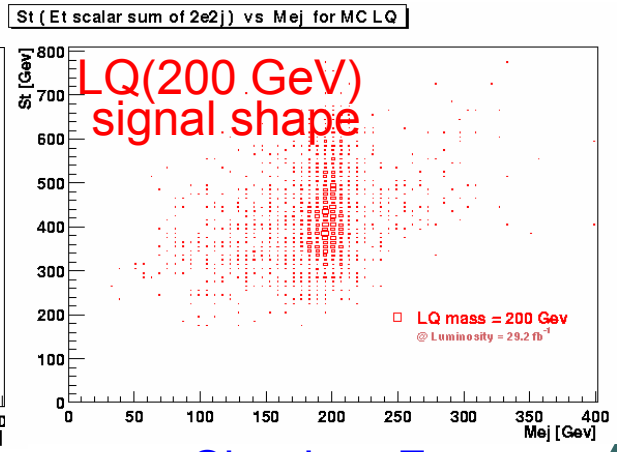
Pavel Demine

Leptoquark Search in the eejj Channel

- Leptoquarks: hypothetical particles with properties of both quarks and leptons; restore symmetry between the two
- Search strategy: motivated by the well-optimized Run 1 analysis:
  - Kinematic cuts: 2 EM objects w/ E_T > 25 GeV and at ≥2 jets w/ E_T > 20 GeV
  - Use S_T – scalar sum of transverse energies of electrons and jets to separate signal and background
  - Additional variable: two pair masses M(ej) for the combination that gives the closest match between the two
- Five events survive these cuts (in ~5 pb^{-1}); one has a track match
- The most energetic event has S_T = 315 GeV (Run 1 cut was at 350 GeV) and no track match

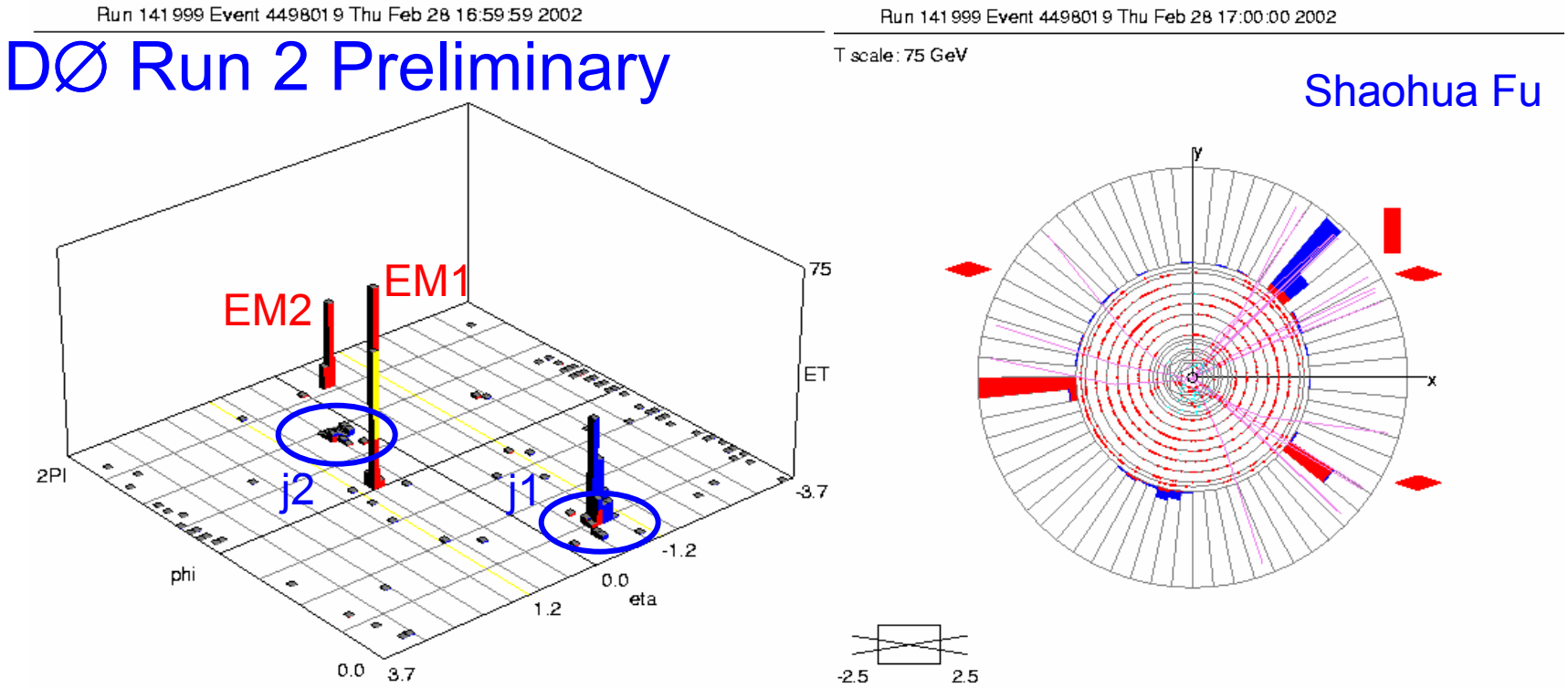






Shaohua Fu

Highest S_T eejj Candidate Event



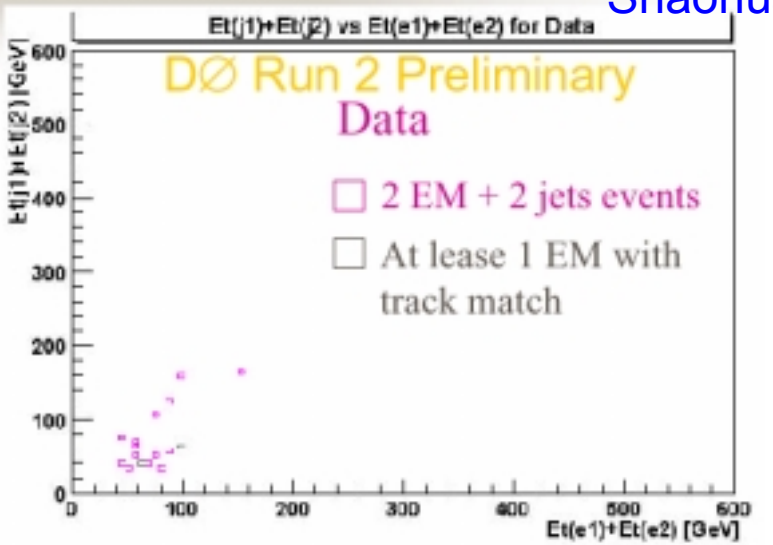
EM1	EM2	j1	j2
E_T = 113 GeV η = 0.60 φ = 3.23 No track match	E_T = 39.5 GeV η = -0.82 φ = 5.65 Low p_T track match	E_T = 129 GeV η = -1.03 φ = 0.78	E_T = 33.8 GeV η = 0.08 φ = 4.48
S_T = 315 GeV; M_{ee} = 162 GeV; M_{ej} = 81 GeV, 97 GeV			

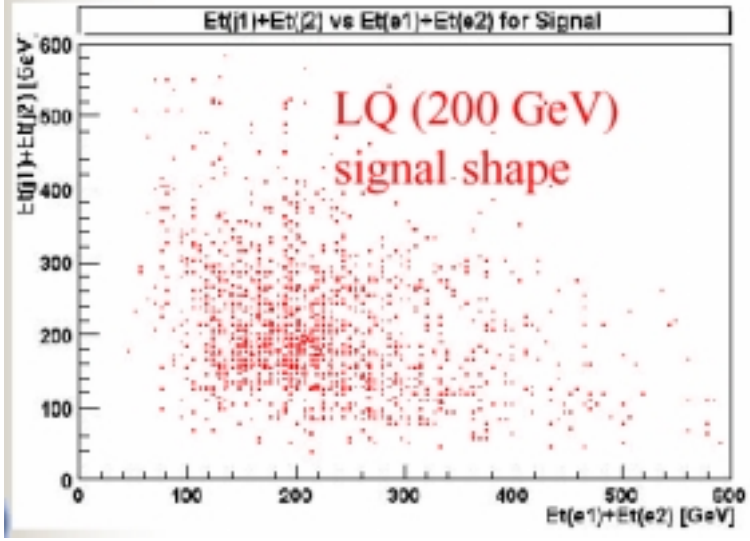
Since the Moriond

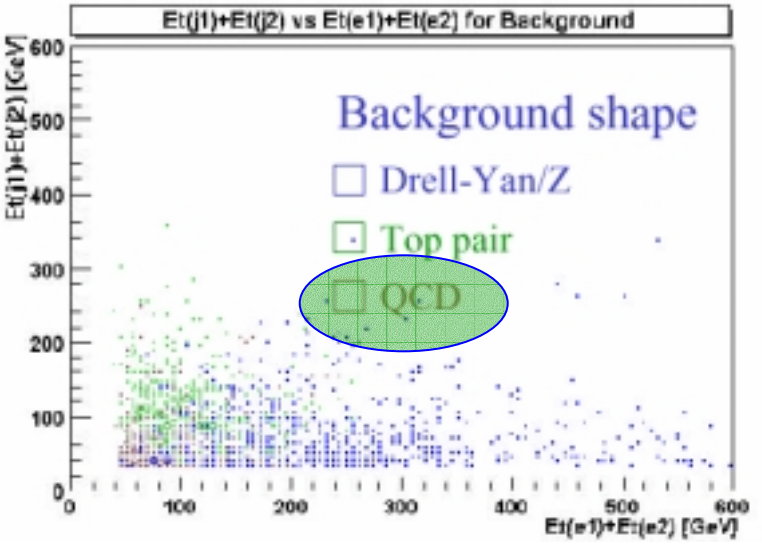
Shaohua Fu

- Run II data, event selection:
  - 2 EM objects E_T>20 GeV
  - ≥2 jets E_T>15 GeV
- 16 events survived these cuts
  2 events with track match

$E_T(j1)+E_T(j2)$ vs. $E_T(e1)+E_T(e2)$ plots

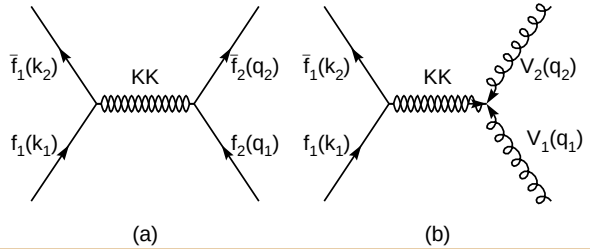


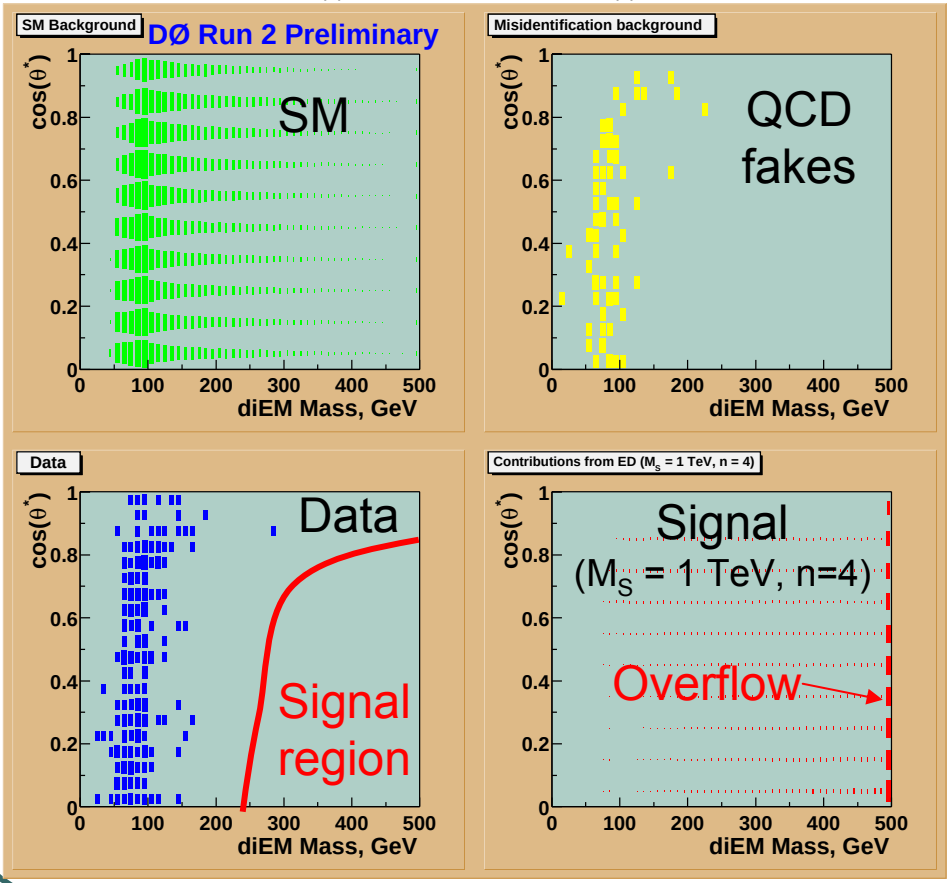




Search for Extra Dimensions

GL





- Search for large extra spatial dimensions via virtual graviton effects
- Approach inspired by the DØ Run 1 analysis: employs the mass and the c.o.m. scattering angle to maximize sensitivity
- Use diEM, ($\gamma\gamma$ and ee) events to further increase sensitivity
- Kinematic cuts: E_T(EM) > 25 GeV, good fiducial volume; standard EM ID
- Background is dominated by Drell-Yan and direct photon production
- Data agree qualitatively with the background predictions
- The highest-mass (286 GeV) candidate event has forward topology, typical of background

The Most Massive Candidate Event

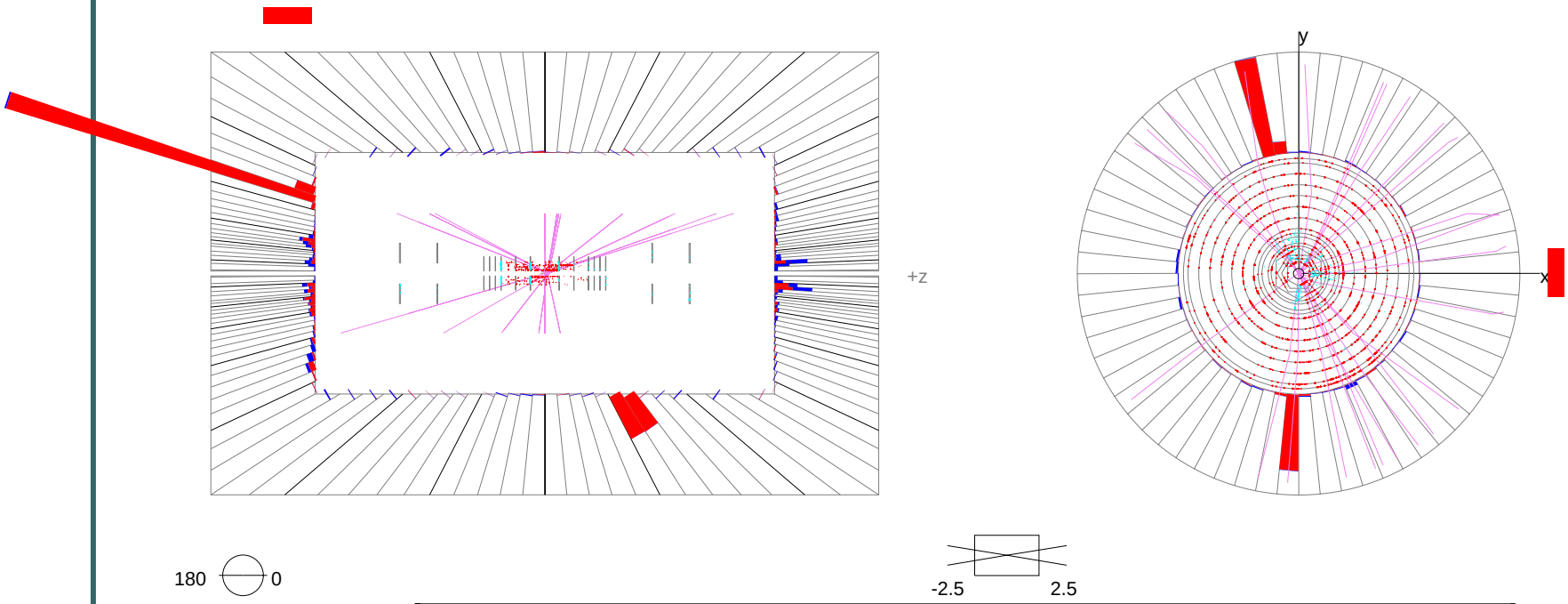
Run 142645 Event 640762 Tue Feb 26 13:36:55 2002

Run 142645 Event 640762 Tue Feb 26 13:36:56 2002

E scale: 80 GeV

ET scale: 76 GeV

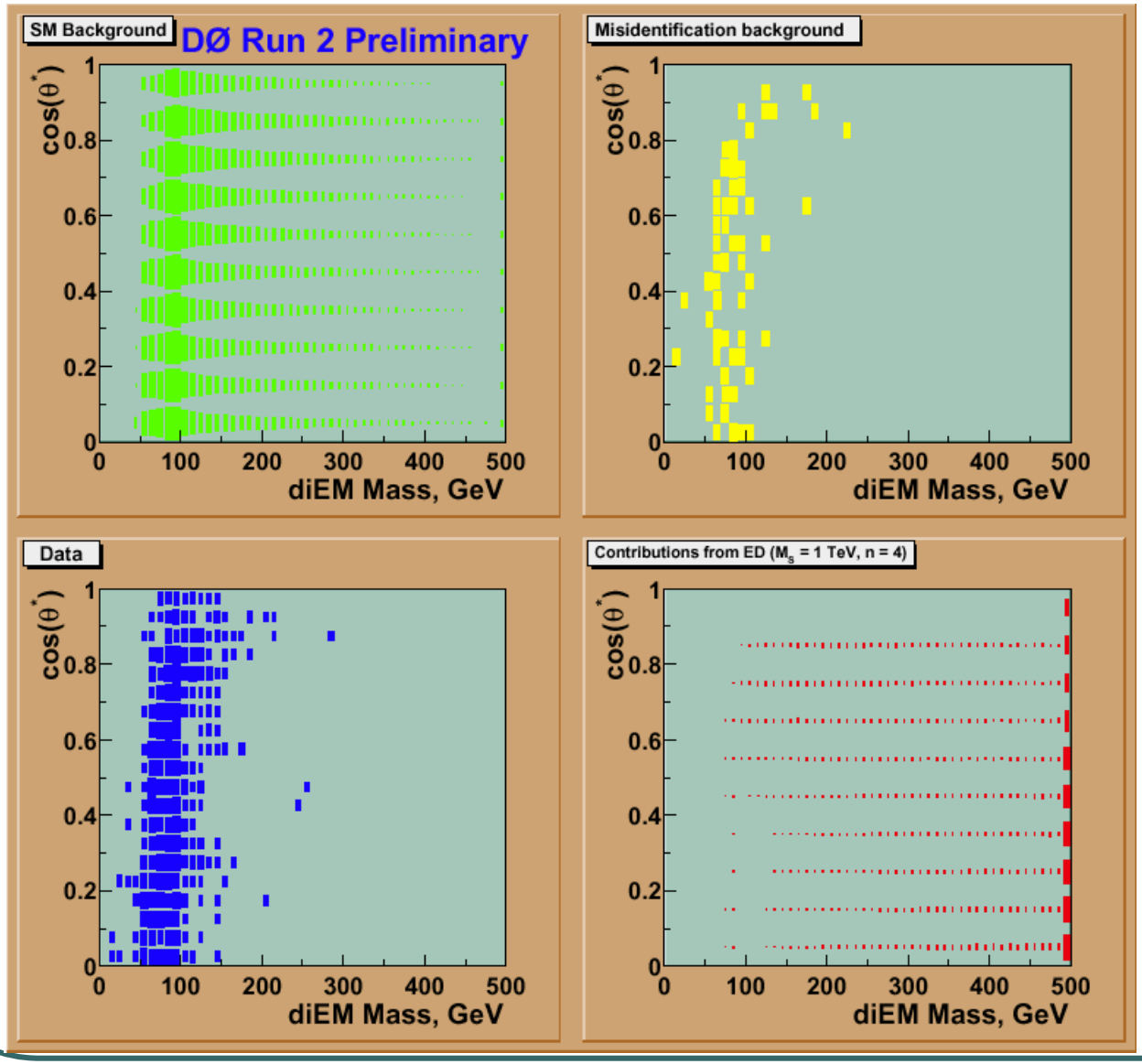
GL



EM1	EM2
E_T = 91.1 GeV η = -1.83 φ = 1.79 Loose low p_T SMT track match	E_T = 67.1 GeV η = +0.60 φ = 4.65 Loose low p_T CFT track match
M(diEM) = 286 GeV; cosθ* = 0.90; ME_T = 25.9 GeV;	

Since the Moriond

GL

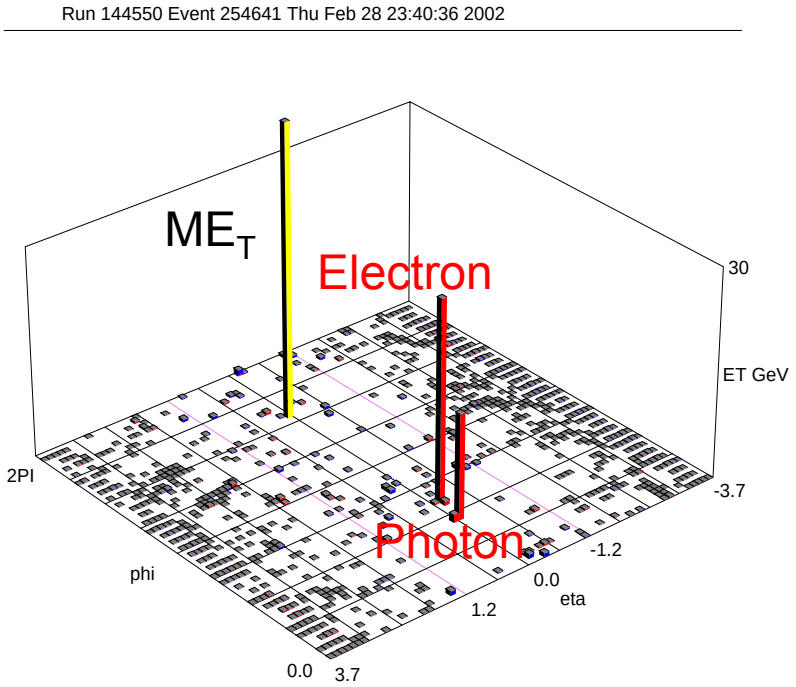


Much more data, backgrounds will drop dramatically with new HM

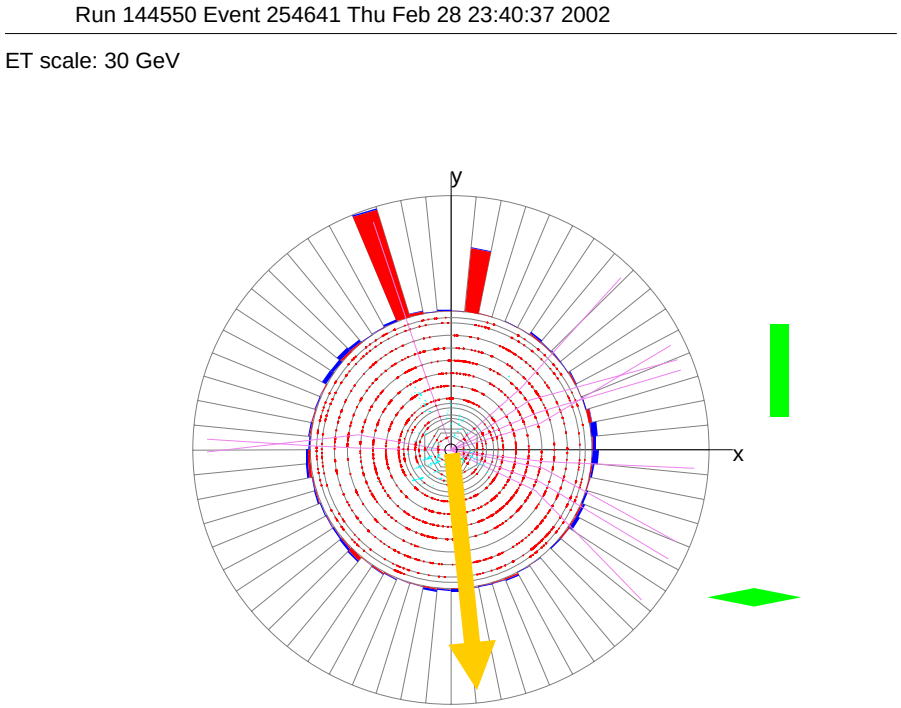
Dimuon channel analysis is in progress (Ryan Hooper)

Wγ Candidate Event

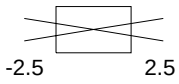
GL



Wγ events are found in radiative W-decays and also models w/ anomalous VB couplings and other new physics scenarios



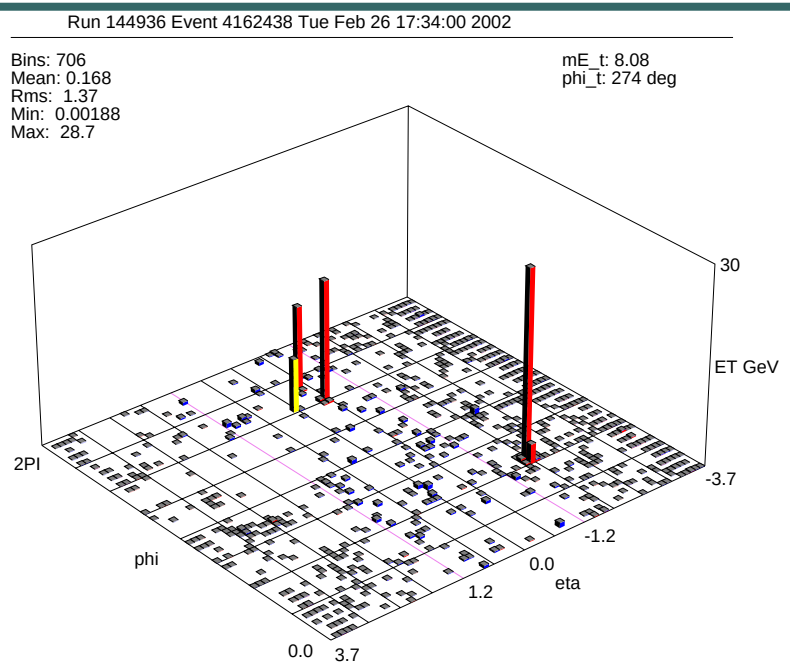
e	γ
E_T = 31.8 GeV p_T = 16.4 GeV η = -0.13 φ = 1.89 Charge = -1	E_T = 17.8 GeV η = -0.01 φ = 1.42 No track match
M_T(e-ME$_T$) = 76 GeV, M_T(eγ–ME$_T$) = 95 GeV ME$_T$ = 45 GeV	



DØ Run 2 Preliminary

Zγ Candidate Event

GL



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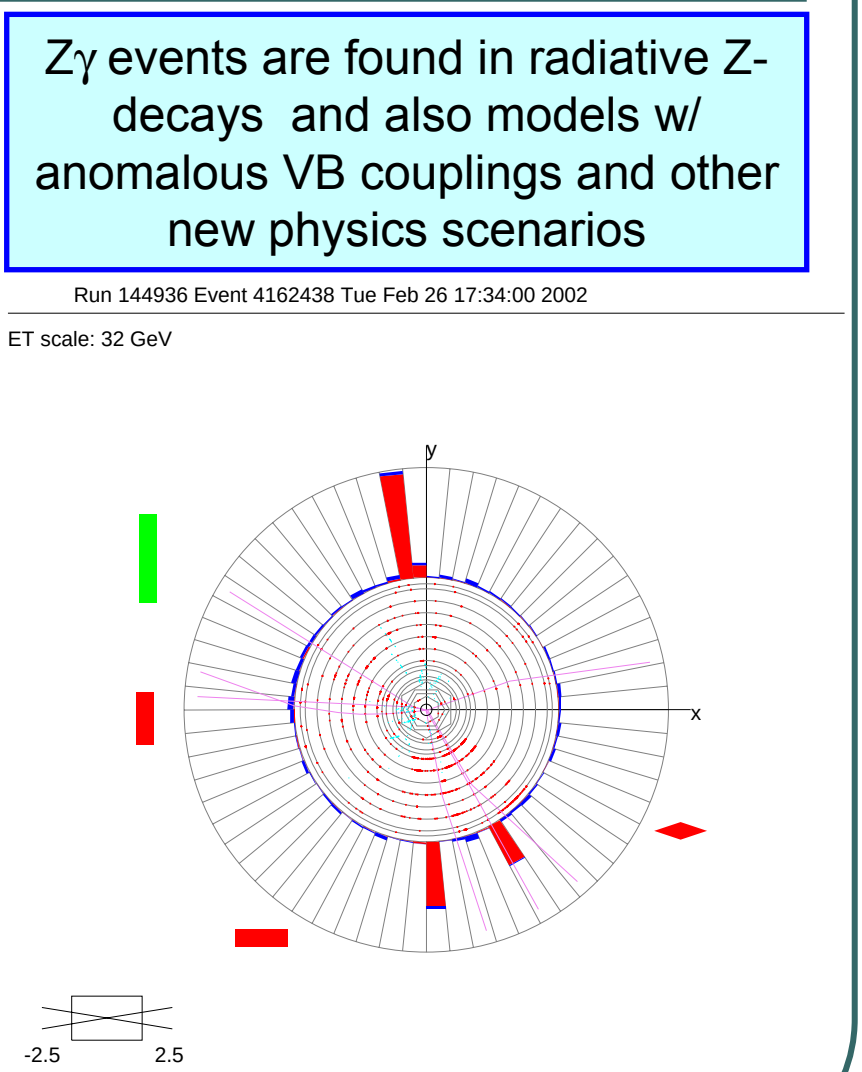
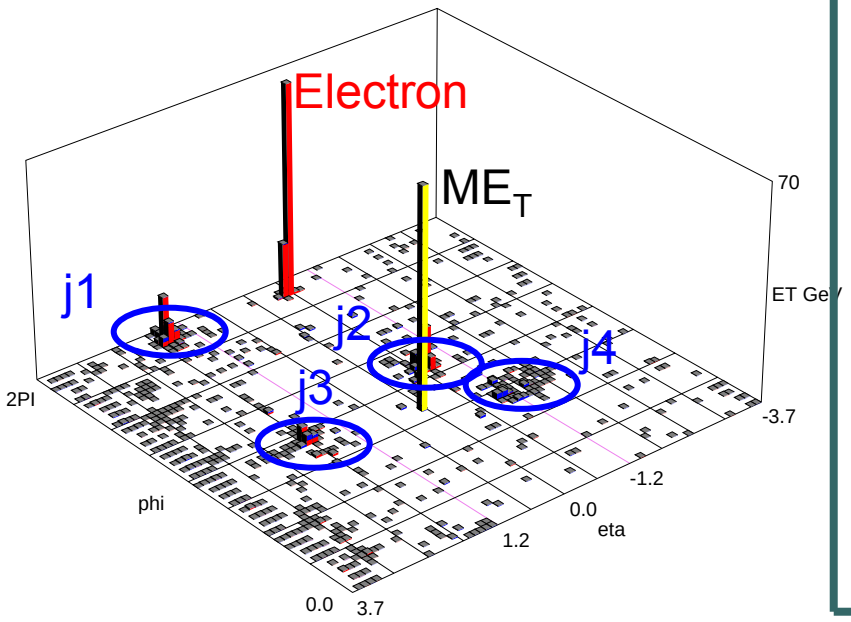


e1	e2	e3
E_T = 39.4 GeV η = -1.76 φ = 1.68 No track match	E_T = 23.9 GeV η = -0.52 φ = 4.74 No track match	E_T = 15.6 GeV p_T = 12.0 GeV η = -0.45 φ = 5.22 Charge = -1
$M(e_1e_2)$ = 75 GeV, $M(e_1e_3)$ = 61 GeV, $M(e_2e_3)$ = 9 GeV; M(eee) = 97 GeV; ME_T = 7 GeV		

DØ Run 2 Preliminary

W+4 jets Candidates

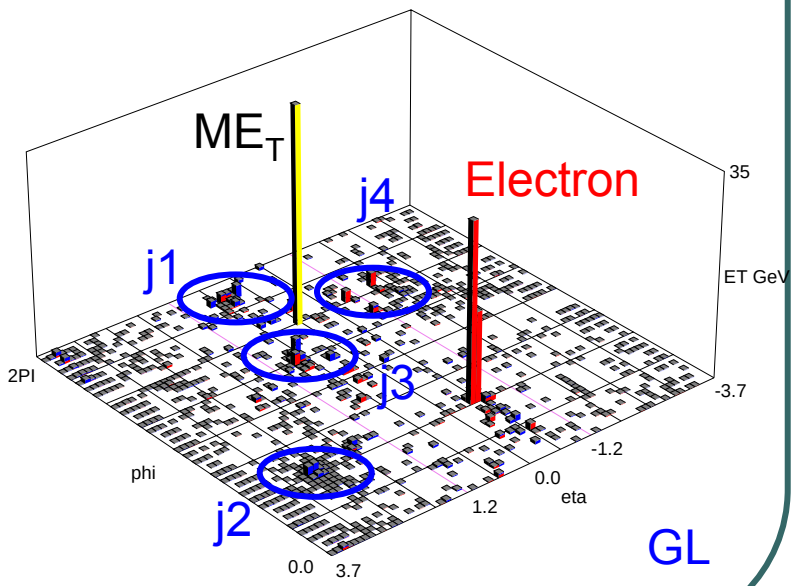
Run 141155 Event 154798 Thu Feb 28 01:44:52 2002



DØ Run 2 Preliminary

e1	j1	j2	j3	j4
E_T = 52 GeV η = -0.51 φ = 1.63 Low-p_T track match	E_T = 28 GeV η = 0.73 φ = 3.82	E_T = 24 GeV η = 2.41 φ = 1.62	E_T = 21 GeV η = 0.52 φ = 5.80	E_T = 20 GeV η = -1.43 φ = 4.60
ME$_T$ = 30 GeV, M$_T$(EM-ME$_T$) = 79 GeV				

Run 142344 Event 1669603 Thu Feb 28 01:42:39 2002



e1	j1	j2	j3	j4
E_T = 99 GeV η = -0.53 φ = 5.94 Low-p_T track match	E_T = 68 GeV η = 1.62 φ = 6.03	E_T = 57 GeV η = 0.69 φ = 3.38	E_T = 35 GeV η = 1.27 φ = 2.29	E_T = 26 GeV η = 1.83 φ = 2.90
ME$_T$ = 62 GeV, M$_T$(EM-ME$_T$) = 156 GeV				

DØ Run 2 Preliminary

Other Conferences

- APS conference – a success!
  - Steve Doulas – Heavy Slow-Moving Charged Particles
  - Shaohua Fu – Search for First Generation Leptoquarks
  - Pavel Demine – RPV SUSY Searches
  - Brent Wang – RPV SUSY Searches in Likesign Dielectrons
  - Daniel Whiteson – Inclusive eμ Data Set
  - Hai Zheng – First Search for ED in the Monojet Channel
- Madison Pheno 2002 - ongoing
  - Auguste Besson – RPV SUSY Searches
- DPF – late May
  - Yuri Gershtein – GMSB SUSY in the $\gamma\gamma$+ME_T Channel
  - Ryan Hooper – Searches for Extra Dimensions
  - Alex Melnitchouk – Search for Fermiophobic Higgs $\rightarrow \gamma\gamma$
  - Zeno Greenwood – Search for First Generation Leptoquarks

Next Steps

- Spring conference performance was good, but it is too early to relax, since the next round of summer conferences is really about RESULTS, not just nice PLOTS!
- We have to:
  - Demonstrate quantitative agreement between the data & the sum of the backgrounds;
  - Set limits on new physics in the channels we are going to present;
  - Identify interesting candidate events and show them (with caution!)

ICHEP Strategy

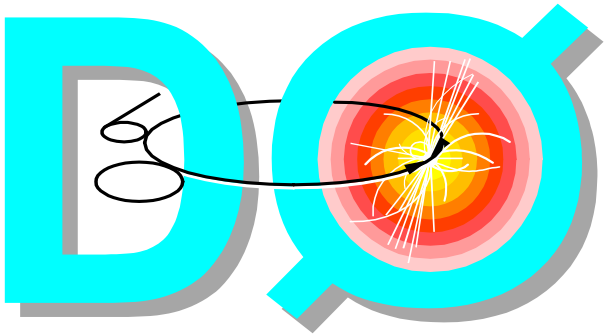
- We decided to submit four general abstracts:
  - Search for Exotics at DØ
    - Leptoquarks: eejj, μμjj ?
    - Extra dimensions: ee, γγ, μμ ?
  - Search for RPV SUSY at DØ
    - Likesign dileptons
    - Trileptons
  - Search for SUSY in SUGRA-inspired models
    - Trileptons
    - b-squark searches (?)
    - squark/gluino searches (?)
    - eμ–channel
  - Search for SUSY in GMSB-inspired models
    - $\gamma\gamma$+ME_T
    - Long-lived particles (?)

Many Open "Drive-Thru" Channels

- Anything with τ: τ–ID desperately needs your help; τ's are essential for new physics!
- Trigger development: ME_T+X triggers
- Trileptons are overrated; think creatively:
  - e+jets+ME_T (leptoquarks!)
  - μ+jets+ME_T (leptoquarks!)
  - likesign dimuons
  - τ-channels
- W', TC search; compositeness in lepton channels
- γ+jets+ME_T
- This is your chance to make a fast analysis with visible impact; if you wait too long, somebody else will do it instead!
- We are here to find "zoo" events – our detector produces ~1/day – until you understand those, don't dream of finding real new physics
- The time to join is NOW – and it is FUN!

Conclusions

- An exciting year for exciting physics!
- Data samples are still small, but the sensitivity is not: higher energy, new detector capabilities
- Weekly, if not daily improvements – a great time to use physics input to fix the detector and software problems
- We MUST come strongly at the ICHEP, so let's

just  it!